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Estimating Nitrogen Losses

by John Sawyer, Department of Agronomy

Many areas of central to southern Iowa have experienced well above normal rainfall this spring, with several large rainfall events (see map). In the early spring, cold soils help reduce potential for nitrate-N loss due to slow accumulation of nitrate and slow denitrification. However, continued wet soil conditions into June with warm soils, prolonged saturation and tile drainage enhance nitrate loss.

One way to determine nitrogen (N) loss is to calculate an estimate. Predicting the exact amount is quite difficult as many factors affect losses. However, estimates can provide guidance for supplemental N applications.

Research Measurement of Nitrate Loss

Research conducted in Illinois* indicated approximately four to five percent loss of nitrate-N by denitrification per day that soils were saturated. An all-nitrate fertilizer was applied when corn was in the V1 to V3 growth stage (late May to early June). Soils were brought to field capacity and then an excess four inches of water (above ambient rainfall) was applied by irrigation evenly over a three-day period (which maintained saturated soils for three to four days on the finer textured soils) or an excess of six inches of water was applied over an eight-day period (which saturated soils an additional three to four days).

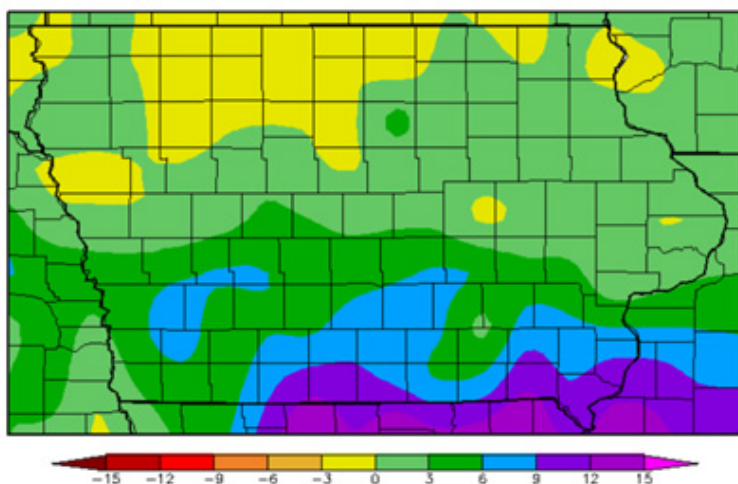
The excess water application resulted in loss of 60 to 70 pounds N/acre on silt loam and clay loam soils, due to denitrification loss. On a very coarse-textured, sandy soil, virtually all nitrate-N was moved out of the root zone by leaching. On the finer textured soils, an addition of 50 pounds N/acre after the excess water was sufficient to increase corn yields to approximately the same level where no excess water was applied. This was not the case on the sandy soil because considerably more N was lost due to leaching.

Nitrate loss via tile drainage does increase with above normal rainfall. At the Gilmore City, Iowa ag-drainage research site where tile-flow nitrate has been monitored since 1990, nitrate loss is greatest in years with higher precipitation and hence greater tile flow. At N fertilization rates of 150 to 160 pounds N/acre, the annual nitrate-N loss per acre was 52 pounds in the 1990-1993 period, 9 pounds in the 1994-1999 period, and 39 pounds in the 2000-2004 period (average nitrate-N losses for the combined corn-soybean sequence). The range in yearly nitrate-N loss for the years studied was 1.0 pound nitrate-N/acre in 1997 to 75 pound nitrate-N/acre in 1990.

Typically a high portion of tile flow and associated nitrate-N loss occurs in the springtime. The impact of excess precipitation on potential for nitrate remaining in the soil for crop use in wet springs like this year is that more nitrate-N is lost via tile flow, and overall the annual loss would be in the range of perhaps twice the "normal" loss amount, increasing from around 15-25 pounds N/acre to 40-50 pounds N/acre.

Departure from Normal Precipitation (in)

4/15/2010 – 6/13/2010



Generated 6/14/2010 at HPRCC using provisional data.

NOAA Regional Climate Centers

Estimating

Precipitation departure map from the High Plains Regional Climate Center, Applied Climate Information System

(<http://www.hprcc.unl.edu/maps/>).

Nitrate Loss

According to research at the University of Nebraska, the estimated denitrification loss of nitrate when the soil temperature is 55 to 60 degrees F is 10 percent when soil is saturated for five days and 25 percent when saturated for 10 days (2 to 2.5 percent per day). Loss increases with warmer soils. Illinois research conducted in late May to early June (soil temperatures greater than 65 degrees F) with excess application of water on silt loam and clay loam soils indicated approximately four to five percent loss of nitrate present per day that soils were saturated.

To estimate N loss, the first step is to estimate the amount of ammonium converted to nitrate-N. By now, one might assume late fall anhydrous ammonia and manure ammonium to be nearly converted to nitrate, and with early April preplant N applications, much more than 50 percent converted to nitrate. Less conversion to nitrate would occur with use of a nitrification inhibitor. Recent ammonium applications (within the last two weeks) would still be predominantly in the ammonium form, especially for anhydrous ammonia. Recent application of nitrate-containing fertilizers would result in more nitrate being present. Urea-ammonium nitrate solutions (28 or 32 percent UAN) contain one-quarter nitrate-N, and nitrify more rapidly. The second step is to estimate the percentage of nitrate-N loss as described in the research above. The amount of N loss is calculated from these two estimates.

Example

The following might be an example of a situation with a spring preplant application of UAN solution and the wet conditions encountered this year. If 85 percent of a 120 pound N application is converted to nitrate, and soils were then saturated for 10 days when warm, the N loss estimate would be $(120 \text{ pounds N per acre} \times 85 \text{ percent nitrate}/100) \times (4 \text{ percent per day}/100) \times (10 \text{ days}) = 40 \text{ pounds N per acre}$. Add in increased tile flow on tile-drained fields, and the loss estimate could be 60 pounds N per acre. Variation of lower or higher losses could easily occur depending on warmer or cooler conditions, different forms of applied N, more or less time from N application to wet conditions and more or less time and frequency soils are saturated. The same will occur for different landscape positions and soils. With very coarse-textured/sandy soils, significant rainfall events (four to six inches or more) in addition to already moist soils could easily result in all nitrate leaching out of the crop rooting zone.

**Reported in the 1993 Iowa State University Integrated Crop Management Conference proceedings, pp. 75–89, and in Torbert et al., 1993, “Short-term excess water impact on corn yield and nitrogen recovery,” Journal of Production Agriculture 6:337–344.*

John Sawyer is a professor of agronomy with research and extension responsibilities in soil fertility and nutrient management.

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